*DOI:*
10.1016/j.shpsc.2017.07.002

*Document Version*
Peer reviewed version



*Citation for published version (APA):*
Manias, C. (2017). Progress in Life's History: Linking Darwinism and Palaeontology in Britain, 1860-1914. Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences. https://doi.org/10.1016/j.shpsc.2017.07.002

# Progress in Life's History:

# Linking Darwinism and Palaeontology in Britain, 1860-1914


## ABSTRACT

This paper examines the tension between Darwinian evolution and palaeontological research in Britain in the 1860-1914 period, looking at how three key promoters of Darwinian thinking – Thomas Henry Huxley, Edwin Ray Lankester and Alfred Russell Wallace – integrated palaeontological ideas and narratives of life's history into their public presentations of evolutionary theory. It shows how engagement with palaeontological science was an important part of the promotion of evolutionary ideas in Britain, which often bolstered notions that evolution depended upon progress and development along a wider plan. While often critical of some of the non-Darwinian concepts of evolution professed by many contemporary palaeontologists, and frequently citing the 'imperfection' of the fossil record itself, Darwinian thinkers nevertheless engaged with palaeontology to develop evolutionary narratives informed by notions of improvement and progress within the natural world.


## 1.1 INTRODUCTION

Palaeontology had a problematic position within Charles Darwin's initial promotion of the theory of evolution by natural selection. On the one hand, fossil evidence and understandings of an immeasurably long geological timescale were essential for illustrating that species had varied in the past, and that there was sufficient time in earth's history for the slow process of natural selection to lead to new forms. Darwin also personally engaged in palaeontological collecting work, and the South American fossils he retrieved during the Beagle Voyage were of significant interest to palaeontologists (Brinkman 2010a, Podgorny 2017). However, the state of palaeontological knowledge in the mid-nineteenth century also posed problems, which threatened to unsettle the theory if not carefully qualified. In *The Origin of Species*, Darwin highlighted both 'the imperfection of the fossil record' (Darwin, 1859, pp. 279-311) and the lack of records of any fossils below the Silurian (Darwin, 1859, pp. 463-5) as major problems for his theory that future research would be needed to rectify. Modern palaeontological collections were cited as being inadequate for this task, with Darwin lamenting: 'turn to our richest geological museums, and what a paltry display we behold!' (1859 p. 287).

For their own part, nineteenth-century palaeontologists have often been presented as having a difficult relationship with Darwinian evolution. The fragmentary nature of the palaeontological record ensured that demonstrating mechanisms like natural selection using fossils was difficult, and identifying the gender differences necessary for the even more contested issue of sexual selection was also problematic. While palaeontologists in the latter part of the nineteenth century moved increasingly to 'tree' modes when depicting life's history which were akin to Darwinian ideas of branching change (Pietsch 2012), many still often conceptualized important strands of palaeontological development in terms of linear progress. There was also a tendency among many palaeontologists, such as Albert Gaudry in France or Edward Drinker Cope in the USA, to make references to metaphysical forces or 'plans' in nature. This ensured that there was always a strong strand within palaeontology which went against the random and non-hierarchical view of nature which structured Darwin's theory.

As a result, palaeontology has often been taken as a key source of support for non-Darwinian forms of evolution, with Peter Bowler presenting it as one of the most striking manifestations of the 'Eclipse of Darwinism,' and a major source of support for alternate theories Neo-Lamarckianism, orthogenesis and saltationism (Bowler, 1983 and 1996). It is certainly true that palaeontologists – and particularly those in France, Germany and the United States –were some of the leading promoters of these ways of thinking about evolutionary development, both before and after 1859. In Britain, the comparative anatomy of Richard Owen, which strongly resisted the implications of Darwinian thinking (and transmutationist ideas more generally), also drew a great deal from palaeontology (Desmond, 1984, Rupke, 2009 and Camardi 2001). While Owen's programme did not survive his death, later British palaeontologists, such as Harry Govier Seeley, Richard Lydekker (Bowler, 1996) and Robert Broom (Richmond, 2009) resisted strictly Darwinian ideas in favour of more metaphysical concepts well into the twentieth century.

Whether this frequent use of non-Darwinian ideas in palaeontology marks out the field as an area of theoretical innovation (albeit of ideas which were later rejected in the synthesis period) or as an odd cul-de-sac separated from the more 'mainstream' life-sciences is an open question that this special edition will hopefully go some way to resolving. However, it is important to note that palaeontology was an expanding and dynamic field in this period, and rejecting the role of non-Darwinian evolutionary theorists and models potentially risks imposing current views on evolution on nineteenth-century conceptions (Bowler, 2005, pp. 28-29). As shown in much recent work on the history of palaeontology (Rainger, 1991, Brinkman, 2010, Nieuwland, 2010, and Rieppel, 2012), the discipline was undergoing tremendous expansion in Europe, the USA and globally in this period, and gaining a great public profile. As a result, it could not be easily written off by more self-consciously 'Darwinian' thinkers – and indeed, was increasingly essential to engage with.

This paper will examine some of more direct confluences between Darwinian thinking and palaeontology by looking at how three key promoters of 'Darwinism' in public life in Britain – Thomas Henry Huxley, E. Ray Lankester and Alfred Russell Wallace – engaged with evidence and theories deriving from the expanding field of palaeontological research. It will primarily focus on their more popular writings, where they deployed evidence from life's history to explain evolutionary development to wider audiences. This was an increasingly important part of scientific activity in this period, essential to gaining both support and recognition, and also for asserting the significance of life's history for wider issues of evolution, nature, and progress. In doing so, this paper will engage with how palaeontological research was integrated into more explicitly Darwinian modes of thinking in this period, and how we can conceptualize the relations between 'Darwinian' and 'non-Darwinian' concepts.

Broadly, the article agrees with the line that what could be called 'Darwinism' in the 1870-1914 period often resonated strongly with contemporary notions of progress and development. This is an idea which has become widely presented in much recent literature (often taking a lead from Ruse, 2009), which is moving away from anachronistic back-readings of the post-1945 synthesis biology onto this earlier period. However, it develops these concepts by noting that in this reconciliation of progress and Darwinian thinking, the incorporation of ideas and models from the increasingly important field of palaeontology played a significant role. Palaeontological finds and theories could give scholars committed to promoting Darwinism a powerful set of images and resources, strongly committed to narratives of development and progress – both in nature and in modern science. Far from attempting to sideline palaeontological research as was often a feature in Darwin's own writings, invoking the importance of palaeontology was a key strategy for gaining appeal and honing models throughout this period.

## 1.2 THOMAS HENRY HUXLEY & THE AMERICAN ADDRESSES

Some of the earliest attempts to weld palaeontological research with an explicit commitment to Darwinian models of evolution were presented by Thomas Henry Huxley (1825-1895) – something possibly unsurprising given Huxley's status as an important Victorian public intellectual, and his role in the public presentation of Darwinian thought. In some ways, Huxley's extensive invocation of palaeontological finds and discoveries filled in gaps in Darwin's own arguments, bringing the fossil record more clearly to bear on evolutionary processes. However, the use of palaeontology also caused ideas of progress and teleology in nature to come strongly to the fore.

Huxley engaged with palaeontological discoveries and debates throughout his career. This ranged from studying individual specimens, to writing popularizing accounts and specialist papers, and communicating with some of the leading figures involved in palaeontology. In Britain, his fierce debates with Richard Owen have been widely examined (Desmond, 1984 and Rupke, 2009 pp. 182-208), and he was also involved in training and educating future generations of scientists who would go on to become important palaeontological researchers. Internationally, he engaged with palaeontologists in both continental Europe and the USA, and some of the leading American palaeontologists of the next generation, most notably William Berryman Scott, eventually Professor of Geology at Princeton, and Henry Fairfield Osborn, future President of the

American Museum of Natural History in New York, spent part of their education in Britain specifically training under Huxley. As a participant in the networks of the life sciences in this period, Huxley was a key force.

Huxley presented palaeontology as an extremely important contributor to understanding life, rather than something that raised problems in theoretical models. It was not just a source of evidence, but a source of theoretical innovation. Indeed, Huxley expressly mocked the use of palaeontology by many comparative anatomists by citing the (then) well-known maxim of the engineer James Brindley, that "'Rivers," … "were made to feed canals," likening this to how 'geology, some seem to think, was solely created to advance comparative anatomy.' (Huxley, 1862a, p. 273) Huxley felt that these conceptions were too narrow minded. Palaeontology certainly needed to be understood as providing evidence for evolutionary development and the narrative of life's history. However, it also provided a great deal of the theoretical base on which evolutionary ideas rested: 'allied with geology, paleontology has established two laws of inestimable importance: the first, that one and the same area of the earth's surface has been successively occupied by very different kinds of living beings; the second, that the order of succession established in one locality holds good, approximately, in all.' (Huxley, 1862a, p. 275). In understandings of both life's history and modern biogeography, palaeontology was crucial for presenting the raw evidence, but also giving important lessons on process in its own right.

Indeed, in Huxley's writings on palaeontology, he frequently asserted the importance of palaeontology and geology – often using the much longer public engagement with life's history through these subjects (as depicted in O'Connor, 2007) to lend support for the potentially more controversial aspects of Darwinian thinking. Indeed, in one of his earliest defences of Darwin's theory, he aimed to show how 'Mr. Darwin's work is the greatest contribution which has been made to biological science since the publication of the "*Règne Animal*" of Cuvier,' (T. H. Huxley 1862b) and included a long discussion of how Darwin's theories were not only completely consistent with a range of palaeontological finds and discoveries, but were their best explanation. Gradual evolutionary modification and continuity in life's history explained why fossil animals mirrored modern forms in particular regions, such as the ground sloths and glyptodons in South America, the fossil marsupials in Australia, and the aurochs, mammoth and woolly rhinoceros in the Old World. (Huxley, 1862b, p. 144). Palaeontology showed that life changed throughout time, in a regular manner which created consistent life histories for particular regions.

It was not just the historical development and discoveries of palaeontology which could support Darwinian evolution. More generally, Huxley also expressed a great deal of faith in the future progress of palaeontology itself. Like Darwin, Huxley often noted that the 'imperfection of the fossil record' meant that palaeontological narratives needed to be treated with caution. However, this tended not to be styled so much as a problem, but as an opportunity. By 1881, in a lecture entitled 'On The Progress Of Palaeontology,' (Huxley, 1881) Huxley noted that palaeontologists were steadily filling the gaps in the fossil record of a whole series of animal lineages. Recognizing the international scope of the discipline, Huxley highlighted how 'the labours of Gaudry, Marsh, and Cope furnish abundant illustrations of this law from the marvelous fossil wealth of Pikermi and the vast uninterrupted series of tertiary rocks in the territories of North America.' Palaeontologists were presenting the evolutionary histories of a range of familiar animals, and beginning to show general laws of 'gradually increasing specialisation of structure.' (Huxley, 1881, p. 42) The recent history of palaeontological research was filling the gaps in the fossil record, and providing evidence of slow and incremental transmutation of species, and raising hopes that ever-increasing evidence would appear in the future.

Moreover, this faith in palaeontological reasoning ensured that a level of speculation was a viable tool of scientific analysis and deduction. In one of his addresses, 'On the Method of Zadig' (Huxley, 1880) Huxley referred to a story from Voltaire of a Babylonian sage who was able to identify a horse from its footprints (a story which was widely invoked by paleontologists going back to Cuvier, and has recently been discussed in Cohen 2011). Huxley drew this analogy completely. He stated that 'the whole fabric of palaeontology, in fact, falls to the ground unless we admit the validity of Zadig's great principle, that like effects imply like causes.' (Huxley, 1880, p. 13) Palaeontological finds meant that Zadig's mode of conjectural reasoning from small pieces of evidence could be carried beyond comparative anatomy. It was not only the features of fragmentary individual organisms which could be reconstructed through predictive methods, but also the intermediaries between potentially related forms:

> And if this be the case, the late advances which have been made in palaeontological discovery open out a new field for such prophecies. For it has been ascertained with respect to many groups of animals, that, as we trace them back in time, their ancestors gradually cease to exhibit those special modifications which at present characterise the type, and more nearly embody the general plan of the group to which they belong. (Huxley, 1880, p. 22)

Postulating hypothetical ancestors or missing links, which palaeontologists of the future would look for to verify, became an important means of driving forward evolutionary science. Any gaps in the fossil record could therefore be a call to action, in both research and deduction, which had to be pursued in tandem to unveil the history of life, and the processes which led to its change.

Huxley's clearest and most widely-read engagement with palaeontology were his *American Addresses* (Huxley, 1877), the collected lectures delivered in New York during his 1876 visit to the United States. These reached a wide audience, being published across the English-speaking world in numerous editions and serializations, and with their core ideas and examples redeployed in a range of other countries and languages. The American dimensions of this work were also of great importance: Huxley's American tour enabled him to visit important collections on the US East Coast, which were developing hugely in scale and beginning to rival those of European museums. The American Addresses were also part of Huxley's developing commitment to scientific popularization, and an idea that this was crucial to the education and enlightenment of the public, and the development of scientific concepts (Jensen, 1991). In this project, palaeontology played a central role, as it provided instructive and dynamic narratives of life's history, and clear examples of the specific changes undergone by organisms in the past.

The main element in Huxley's use of palaeontology in the *American Addresses* was the narrative of life's history established and presented in the geological record, and the argument that this was not only wholly consistent with Darwinian models of evolution, but that the gradual branching transmutation of species was the best possible explanation. The first of the *American Addresses* was devoted to this issue, using palaeontological and geological evidence to argue against the two possible 'competing' hypotheses of life's development, namely that the earth had always existed in its current state (an idea which was brushed aside fairly easily), and then the concept that different 'ages' of the earth corresponded directly with the 'days' of the Genesis narrative, metaphorically stretched to cover a longer chronological period. This was also discounted, with the fossil record showing instead its own series of ages of invertebrates, fish, amphibians, reptiles and mammals, with life becoming gradually more complex and specialized. Citing the discoveries of Cope and Marsh, and long-durational models of geological time, Huxley used palaeontology to present the long chronology required for Darwinian evolution, and also separated the narrative of the history of life on earth from scriptural precedents.

The remainder of the *American Addresses* were devoted to explaining that the gradual step-by-step transmutation of species was the best explanation for the changes observed in the geological record. The discussion of what Huxley called 'Intercalcary Types,' animals 'which overstepped the bounds of existing groups, and tended to merge them into larger assemblages' (Huxley, 1877, p. 59) was a significant aspect of this. Huxley deployed numerous examples of these bridging forms, including some which had been known for decades and others which were more novel. Some of Cuvier's earliest discoveries, the Eocene mammals from the chalk quarries outside Paris like the *Anoplotherium* and *Palaeotherium*, were discussed as undifferentiated intermediates between various types of modern mammal, and possibly their ancestral forms. The more novel evidence was in the transition from reptile to bird, for which the specimen of *Archaeopteryx lithographica*, discovered in Germany in 1861 and purchased by the British Museum of Natural History, was the most striking example. This specimen mixed bird-like, reptilian, and completely distinct characteristics, and 'occupies a midway place between a bird and a reptile' (Huxley, 1877, p. 58). The example did not stop there, however. Huxley moved further along the geological record to discuss *Hesperornis*, a later avian which still retained its teeth, and earlier, discussing *Compsognathus*, a Theropod dinosaur with apparently bird-like features in many of its anatomical details. He noted how 'there is no evidence that *Compsognathus* possessed feathers; but, if it did, it would be hard indeed to say whether it should be called a reptilian bird or an avian reptile.' (Huxley, 1877, p. 66) This all implied that gradual and incremental change between quite distinct 'kinds' of animal could be seen in the fossil record, illustrating both the importance and compatibility of palaeontology and Darwinian ideas of transmutation between classes of organism.

Huxley's most striking example of evolutionary development however was the evolution of the horse, and (deduced from this) that of ungulates more generally – which rapidly became one of the classic models for presenting evolutionary development in the late-nineteenth and twentieth centuries (with some examples being discussed in Clark, 2008, and Gould, 1992). The development of the model of horse evolution was also underlain by one of the classic stories in the history of palaeontology, describing Huxley's meeting with O.C. Marsh in Yale during the American tour, in which the two initially discussed Huxley's tentative hypothesis of the evolution of the horse as a track of increasing specialization:

> At each inquiry, whether he had a specimen to illustrate such and such a point or exemplify a transition from earlier and less specialised forms to later and more specialised ones, Professor Marsh would simply turn to his assistant and bid him fetch box number so and so, until Huxley turned upon him and said, 'I believe you are a magician; whatever I want, you just conjure it up.' (L. Huxley, 1900, 1, p. 495)

This story became one of the great legends of palaeontological research, showing a meeting of minds between the most eminent of the British and American scientists. In many respects, the story represents a switch of batons, entrenching the status of Huxley as theoretically deducing the principles of horse evolution through his predictive method, but also asserting the importance of American science – which had the material – to turn these conjectures into fact. In the remainder of the lecture tour, Huxley integrated Marsh's researches and used a diagram constructed during his conversations with Marsh to show a clear example of regular evolution based on actual specimens.

Huxley's presentation of the evolution of the horse was one of direct and fairly linear change, from the five-toed ancestral form in the Eocene with a small stature and low-crowned teeth, through a variety of intermediaries with steadily decreasing toes and increasing size and tooth complexity, eventually leading to the large modern organism with its one-toe and high-crowned teeth. This provided a clear serial evolutionary example to oppose the main criticisms of palaeontology's relevance to theories of evolution, namely the incompleteness of the fossil record and the lack of evidence of very long-term change. More notably, this serialization was not just limited to horses, but could also be presented as a general rule, and possible model for a range of other organisms. As palaeontological research expanded throughout the world to uncover the lineages of other major mammal groups, it could work out other developmental series: Huxley later noted how this 'has been done fully in the case of the horse, less completely in the case of the other principal types of the ungulata and of the carnivora.' (Huxley, 1881, p. 42)

However, the model of horse evolution was extremely linear and teleological, showing a single line of progress within the lineage. Likewise, Huxley did not really explain the selective pressures which were causing horses to develop in this way. The model simply showed increasing specialization almost as an end in itself, a concept which could also be accommodated within Lamarckian theories, orthogenesis, and other progressivist understandings of evolution – and indeed, later orthogenisists like Henry Fairfield Osborn also deployed Huxley's model of horse evolution extensively (Rainger, 1991). In an earlier work, Huxley went so far as to admit this, that the palaeontological record could potentially support many modes of evolution, not just Darwinian ones: ideas of progressive change and specialization 'would not be absolutely inconsistent with the wild speculations of De Maillet, or with the less objectionable hypothesis of Lamarck.' (Huxley, 1862b, p. 145)

An additional, although possibly counter-intuitive, example used by Huxley to give credence to more specifically Darwinian forms of adaptationist evolution were what he termed 'persistent types' – organisms which had seemingly remained unchanged across long geological periods, potentially including various invertebrate, fish and plant lineages. This preservation of form across incredibly long periods of geological time seemed incredulous if the evolution of life was directed by a set of driving metaphysical processes. Citing the example of non-change demonstrated that there were some organisms whose structure was completely adapted for their environment, and had no more need for change over untold lengths of earth's history – which conversely implied that those types which had changed were driven by some environmental need.

As such, Huxley used a range of palaeontological evidence to support concepts of evolution and development, emphasizing growing specialization, gradual change across geological time, and the importance of palaeontology and its future progress for unveiling the narrative of life's history and the mechanisms driving it. Certain elements of Huxley's presentations did argue against the more metaphysical ideas of evolution which could also potentially be invoked to explain aspects of the fossil record. However, generally, Huxley's use of palaeontology remained driven by a progressivist logic, in terms of the track of life's history, and the role of science itself. It was just one which needed to be understood through material rather than metaphysical forces. In this way, the public linking of palaeontology and evolutionism in this period presented notions of improvement, specialization and progress in the natural and in the human worlds.

### 1.3 Ray Lankester and Spreading Darwinian Palaeontology

Thomas Henry Huxley's presentations had been relatively confident, and saw the natural alignment of palaeontology and Darwinism – drawing on notions of progress, teleology, and fairly linear succession. Moving from the 1880s to the 1900s however, we reach the classic period of the 'Eclipse of Darwinism,' where Darwinian models become contested in a number of areas (Bowler 1983). In the historiography of palaeontology itself, this has also sometimes been invoked as the start of the period in which palaeontology became increasingly isolated from the other life sciences, becoming trapped in its museum-based institutional framework while other subjects orientated more towards laboratory science (Rainger, 1991). The next two sections of this article will examine the ways that two key promotors of Darwinian theory in this contested period, namely E. Ray Lankester and Alfred Russell Wallace, used palaeontology. Both ostensibly aligned themselves with Darwin's theory of evolution, but nevertheless incorporated palaeontological ideas and models for a variety of purposes.

E. Ray Lankester (1847-1929) was an important figure in natural history, initially holding academic positions at University College London and Oxford, and then becoming Director of the British Museum of Natural History between 1898 and 1907 (Ruse 2009 222-228 and 234-241) As a biologist, he was a strong supporter of evolution, and had studied under Huxley early in his career. He is probably most frequently cited for his application of the concept of 'degeneration' – in the 1900s an issue of great popular and artistic resonance, as well as scientific (Pick, 1989) – to ideas of evolutionary development. However, Lankester still maintained a strong conception of progress within the natural world. He was also a committed popularizer of science, particularly in the later 1900s when political difficulties at the Natural History Museum stymied his professional career. In a series of works, including *Extinct Animals* (1905) and *Science From An Easy Chair* (1915), as well as articles for the popular press and the *Encyclopedia Britannica*, Lankester became a key promoter of the life sciences and evolutionary theory in turn-of-the-century Britain.

The need to publicly promote the life sciences led Lankester to use and deploy palaeontology extensively in his works. He expressly noted the ability of prehistoric life to inspire and excite the imagination in the introduction to *Extinct Animals* (1905):

> The whole art of education consists in exciting the desire to know. By showing something wonderful, mysterious, astonishing and marvelous, dug from the earth beneath our feet we may awaken the desire to understand and learn more about that thing. The strangeness of the bones and teeth of extinct animals will lead a boy or girl on to learning about the bones and teeth of living animals in order to make a comparison, and thus to learning more concerning the strange remains dug up. I believe that is usually the case. It certainly was the case with myself … I was absolutely fascinated as a child with the remains I saw of strange extinct animals. (Lankester, 1905, pp. 4-5)

Rather than convince using reason, Lankester was aiming for emotional connection and fascination, using the dramatic side of palaeontology to inspire public audiences towards scientific education. This was not a new idea: indeed, it had something in common with Richard Owen's invocation 'that no specimens of Natural History so much excite the interest and wonder of the public, so sensibly gratify their curiosity, are the subjects of such prolonged and profound contemplation, as these reconstructed skeletons of large extinct animals.' (Owen, 1862, p. 68) However, Lankester was applying contemporary notions of psychology and educational theory, seeing this wonder at the natural world as not just something to gratify curiosity, but as an entry-point to more focused and rigorous interest in the natural world. Indeed, Lankester explicitly opposed this agenda to more factual ways of presenting natural history: the 'logical method of instruction or study is in my judgment a mistaken one. The whole art of education consists in exciting the desire to know.' (Lankester, 1905, pp. 4-5) As knowledge and understanding of the world required marvel and spectacle rather than cold description and citation of 'objective' facts, the 'extinct monsters' of prehistory played an important role.

Darwinian writers could therefore attempt to appropriate the spectacular appeal of palaeontology to generate wider interest - whatever difficulties there might have been with resolving Darwinian forms of evolution with palaeontological evidence and theories. The life of the past stirred the imagination and inspired enthusiasm towards science, which could then be harnessed for deeper understanding. Notably, the years around 1900 in which Lankester was publishing were a period of tremendous expansion of palaeontological knowledge, as it became connected with commerce, spectacle and public appeal. This was particularly marked in the United States, where the 'second dinosaur rush' described by Paul Brinkman unearthed giant sauropods and thrust them into the public domain (Brinkman 2010b; Rieppel 2012). The developments also affected Europe, where casts of these animals were sent to major museums, and large-scale expeditions were organized to colonial territories in order to locate previously unknown organisms (Nieuwland 2010) While Huxley and Darwin had hoped that the future 'progress' of palaeontology would fill crucial gaps in the fossil record, in many instances it had actually presented stranger forms which generated a great deal of interest, but were totally different from any modern animals.

As a result of this, Lankester tended to emphasize the stranger extinct creatures. While Huxley's narratives were focused on the origin of organisms which could either still be seen or which linked familiar classes, Lankester drew attention to creatures that did not have any clear descendants, bringing attention to the strangeness of life in the past. He specifically highlighted the Mesozoic reptiles as 'a prominent example of that kind of extinct animal which is not the forefather, so to speak, of living animals, but of which the whole race, the whole order, has passed away, leaving no descendants either changed or unchanged.' (Lankester, 1905, p. 192) There were multiple reasons for this focus. The first was the aforementioned invoking of wonder to excite interest in natural history. However, there were also other reasons, of showing the diversity life in the past, and how certain creatures had been unable to adapt to developing environmental conditions. The unfamiliar 'extinct animals' could illustrate the radically different environmental conditions that had allowed them to adapt, and the sudden and dramatic changes which caused them to die out. In this way, Darwinian concepts of adaptation, extinction and selection could be shown through the palaeontological record.

Lankester also used some aspects of palaeontology to defend ideas of gradualism and slow incremental change in the development of life. This in many respects continued Huxley's legacy, of arguing that the fossil record – while imperfect – nevertheless still showed the continuous and regular transformation of organisms over geological time. However, these arguments were given a sharper and more direct relevance by the contemporary controversies over mutationism and saltationism which were gaining an increasing prominence in the life sciences – and which the often discontinuous records of vertebrate palaeontology, and seemingly 'monstrous' forms often being excavated, could be used to bolster. A particularly notable engagement with this was a chapter from *Science from an Easy Chair* on *Myotragus*, the 'rat-goat' unearthed by Dorothea Bate in Malta in 1909. This was an odd specimen, which seemed to be an ungulate in most of its features, but which 'monstrously and in a most disconcerting way, protrudes from its lower jaw two great rats' teeth. Nothing like it or approaching it or suggesting it, is known among recent and fossil Ruminants.' (Lankester, 1915, p. 155). Lankester noted that these highly-specialized rodent-like teeth could potentially provide evidence of 'a sudden "sport," a "mutation" as they now call it, and not a result of gradual slowly developed set of adaptations.' (Lankester, 1915 p. 157). However, Lankester was unwilling to countenance this idea, highlighting William Bateson's investigations of museum-collections which showed that discontinuous variation was not a feature of the biological record. Instead, the strangeness of *Myotragus* was explained away by the prediction of earlier, as yet unknown antelope precursors with sharp gnawing teeth, whose remains were either not yet discovered or were submerged beneath the Mediterranean. The imperfection of the fossil record and predictive power of serial thinking was therefore invoked to assert that the the isolated rat-toothed *Myotragus* on the island of Malta was the lone representative of a much longer lineage.

Lankester's works showed slow change over geological time. The core narrative in works like *Extinct Beasts* was of a long-term, gradual series of development, on a slowly cooling earth, which had moved through single-celled organisms, invertebrates, fish, amphibians, reptiles to mammals, and finally humans. Like Huxley's models, this had an implied teleology, with an increase in efficiency, complexity and intelligence occurring over evolutionary time. These developments were accentuated and driven through processes like natural selection, which aimed at an overall improvement across life's history.

The most dramatic element in Lankester's interpretations though were in his views of changes in the form of natural selection in recent geological history. Lankester argued that the history of life showed an increased sophistication and variety of organisms throughout most of geological time. However, he argued from studies of early fossil mammals, particularly the large rhino-like uintatheres and titanotheres of Eocene North America, that the physical development of mammal life had actually reached its fullest development then. While large mammals persisted after this period, they did not become better adapted or more efficient in physical terms, and just continued on similar general plans. From the Miocene onwards, mammals had been relatively stable in their organic structure, and indeed had even declined in their variety and size in many instances – particularly in recent geological eras, which had seen a steady decrease in the size and diversity of animals.

Did this mean though that later evolutionary history was simply a case of degeneration? No, as Lankester instead argued that evolution had switched gears towards a new marker of 'fitness': the development of intelligence. Drawing on the researches of Marsh and Cope, Lankester argued that the uintatheres and titanotheres were distinct from modern mammals in having small, almost reptilian brains. The main structural difference between them and later large ungulates was not in body-size, but in the size of the brain, which seemed to increase over the duration of the age of mammals. In recent evolutionary history, it was the increase of intelligence which was the driving force in natural selection. He expressly argued:

> It seems that we have to imagine that the adaptation of mammalian form to the various conditions of life had in Miocene times reached a point when further alteration and elaboration of the various types, which we know then existed, could lead to no advantage. … Assuming such a relative lull in the development of mere mechanical form, it is obvious that the opportunity for those individuals with the most "educable" brains to defeat their competitors would arise. No marked improvement in the instrument being possible, the reward, the triumph, the survival would fall

> to those who possessed most skill in the use of the instrument. And in successive generations the bigger and more educable brains would survive and mate, and thus bigger and bigger brains be produced. (Lankester, 1907, pp. 23-24)

This notion relates in interesting ways with both palaeontology and contemporary controversies over Darwinian evolution, particularly as applied to humans. The concept of life's history showing a steady increase in brain-size was asserted to be a 'law' of development by the American palaeontologist (and strong supporter of Darwinism) Othniel Charles Marsh. Lankester's invocation of this idea shows the ability of Darwinians to appropriate concepts from palaeontology. Additionally, the notion that the growth of the brain was the major driving force in human evolution, giving early ape-like creatures an ability to triumph in their struggles against nature, was a common (although by no-means uncontested) one, particularly when attempting to explain how weak early humans could have survived alongside fierce prehistoric animals. Lankester here extended these notions significantly. The growth of intelligence was a trend which had taken hold deep in the Age of Mammals, and meant that the appearance of humans was a slow-burning process.

In this context, Lankester's use of palaeontology gave credence to his interpretations of humanity's evolutionary origin and position in relation to the natural world. In his Romanes Lecture of 1905, entitled 'Nature's Insurgent Son,' Lankester explained his views on the relationship between humans and the natural world. He noted that 'Man is held to be a part of Nature, a product of the definite and orderly evolution which is universal,' but yet 'it is his destiny to understand and to control it.' (Lankester, 1907, p. 7) Human power over nature had its roots in the evolutionary past, with recent studies in prehistoric archaeology demonstrating the long duration of human existence, and legitimizing the view 'that Natural Selection began to favour that increase in the size of the brain of a large and not very powerful semi-erect ape.' (Lankester, 1907, p. 15) The rise of intelligence showed a new type of 'fitness': 'not that of "fitness" to the conditions proffered by extra-human nature, but is one of an ideal comfort, prosperity, and conscious joy in life – imposed by the will of man.' (Lankester, 1907, p. 28). Human control over nature and the environment was the new direction of evolution. This again has some parallels with the ideas presented by Huxley in *Evolution and Ethics* (1893) about the position of future human development in relation to 'natural' processes, which argued that humans should aim to protect themselves from the brutal processes of 'Cosmic Evolution,' and instead move to a 'moral evolution' of civilizational progress. Lankester however gave a more direct and combative view of how this would occur: it was not humans escaping natural selection, but dominating it.

For Lankester, the appearance of humans was not just a 'triumph' over brutish processes. It was also decimating the natural world, with human control over the environment destroying modern nature and causing the extinction of many organisms. The long palaeontological background of extinction fed into Lankester's concern over what was occurring in the current world. In a number of articles, he lamented the destruction of nature by humans, most notably the essay 'The Effacement of Nature By Man' (published in *Science from an Easy Chair*). In this piece, Lankester highlighted the brutality and extent of these processes, which had been occurring from the Pleistocene onwards:

> Very few people have any idea of the extent to which man since his upgrowth in the late Tertiary period of the geologists—perhaps a million years ago—has actively modified the face of Nature, the vast herds of animals he has destroyed, the forests he has burnt up, the deserts he has produced, and the rivers he has polluted. It is, no doubt, true that changes proceeded, and are proceeding, in the form of the earth's face and in its climate without man having anything to say in the matter. ... But over and above these slow irresistible changes there has been a vast destruction and defacement of the living world by the uncalculating reckless procedure of both savage and civilised man which is little short of appalling, and is all the more ghastly in that the results have been very rapidly brought about, that no compensatory production of new life, except that of man himself and his distorted "breeds" of domesticated animals, has accompanied the destruction of formerly flourishing creatures, and that, so far as we can see, if man continues to act in the reckless way which has characterised his behaviour hitherto, he will multiply to such an enormous extent that only a few kinds of animals and plants which serve him for food and fuel will be left on the face of the globe. …. He will have converted the gracious earth, once teeming with innumerable, incomparably beautiful varieties of life,

> into a desert—or, at best, a vast agricultural domain abandoned to the production of food-stuffs for the hungry millions which, like maggots consuming a carcase, or the irrepressible swarms of the locust, incessantly devour and multiply. (Lankester, 1915, pp. 365-6)

Humans threatened to destroy the whole of nature, and with it the wonders and marvels that Lankester saw as so important for spreading knowledge and understanding of science. That the earth was undergoing some sort of epochal shift with the appearance of humans and the onset of civilization was a major motif within contemporary discourse. However, in much of Lankester's work, this took on an air of tragedy, as life around the earth was being extinguished by human mastery.

### 1.4 ALFRED RUSSELL WALLACE AND NATURAL PROGRESS

The final figure to be examined is Alfred Russell Wallace (1823-1913), who holds a contested place in the history of Darwinian evolution. On the one-hand, Wallace is frequently presented alongside Darwin as the 'co-discoverer' of the theory of evolution by natural selection. However, the sharp differences which later developed between Wallace and more materialist strands of Darwinism have also been widely noted – particularly in terms of Wallace's support for spiritualism and his claims that natural selection was unable to explain the origin of human consciousness and intellect (Fichman 2001). Despite this, Wallace's role as a promoter of evolutionary theory cannot be overstated. Particularly in the latter decades of the nineteenth century, Wallace became a major public intellectual and promoter of scientific ideas – partly indeed because they were deployed alongside notions like socialism and spiritualism, which were gaining tremendous traction in certain areas of public discourse (Ruse 2009, 195-204). In lectures, articles and larger books like *Darwinism* (1889) and *The World Of Life* (1914), Wallace defended a version of explicitly Darwinian thinking, which were tied to more general holistic visions of nature, but also tackled head-on one of the main controversies over Darwinian evolution, namely the mechanism of natural selection. He noted how Darwin 'did his work so well that "descent with modification" is now universally accepted,' and 'the objections now made to Darwin's theory apply, solely, to the particular means by which the change of species has been brought about, not to the fact of that change.' (Wallace, 1889, p. vi) And in this, Wallace was an inveterate invoker of the primacy of natural selection.

While Wallace's own scientific work did not focus on palaeontology, his more wide-ranging publicizing efforts were replete with examples from palaeontological research. These were often fairly derivative and tended to take their lead from other researchers, including Huxley and Lankester, but also more explicitly non-Darwinian figures, such as Harry Govier Seeley and Richard Lydekker. In this way, these accounts frequently mixed a variety of potential drives. Following Wallace's own increasing interest in metaphysical forces, his works tended to emphasize the progressive and directed nature of development, even if the broad trends of evolution occurred via a natural selection, and in a gradual branching pattern. His overall depiction of natural development was quite similar to that of Lankester, showing an increase in complexity and sophistication of animal and plant life across evolutionary time. He argued that 'the theory of evolution in the organic world necessarily implies that the forms of animals and plants have, broadly speaking, progressed from a more generalised to a more specialised structure, and from simpler to more complex forms,' (Wallace, 1889, p. 375) despite some instances of large-scale extinction and degeneration.

Palaeontology was also an important source of evidence for Wallace. This built into one of Wallace's main intentions in popularizing works like *Darwinism*, which was going beyond the 'weakness in Darwin's work that he based his theory, primarily, on the evidence of variation in domesticated animals and cultivated plants,' (Wallace, 1889, p. vi) to include greater consideration of organisms in 'a state of nature.' As in Darwin's *Origin*, Wallace referred to the 'Imperfection of the Geological Record,' and made similar claims that 'paleontological collections, rich though they may appear, are really but small and random samples,' (Wallace, 1889, p. 380) – even going so far as to make a rough calculation that 'the actual chance against our finding the fossil remains, say of any one order of mammalia, or of land plants, at any particular geological horizon, will be about a hundred thousand to one.' (Wallace, 1889, p. 396) However, the immense expansion of palaeontological research in the intervening decades meant that palaeontology was no longer easy to brush aside. Wallace went on to note that while the global geological record was still patchy, 'certain limited portions of it are fairly complete—as, for example, the various Miocene deposits of India, Europe, and North America,—and that in these we ought to find many examples of species and genera linked together by intermediate forms.' (Wallace, 1889, p. 380). In particular, Huxley's narrative of the development of the horse (now entrenched as a classic example) and William Boyd Dawkins' examination of the increase in size and complexity of deer antlers from the Miocene to the Pleistocene were brought in to give evidence of gradualism and selection in evolutionary history (Wallace, 1889, 384-90). Any sense of incompleteness in the palaeontological record was again more of a call to action and to research the rest of world as extensively as Europe, North America and parts of Asia, rather than a rejection of palaeontological evidence in itself.

Beyond this, Wallace also debated with paleontologists, with an entire section in *Darwinism* arguing against 'The American School of Evolutionists' – particularly directed against Edward Drinker Cope and his Neo-Lamarckian concepts. Wallace took particular issue with Cope's concepts of 'Bathmism,' the evolutionary energy which promoted Lamarckian inheritance through use-and-disuse. These were dismissed as 'theoretical conceptions which have not yet been tested by experiments or facts, as well as metaphysical conceptions which are incapable of proof. And when they come to illustrate these views by an appeal to palaeontology or morphology, we find that a far simpler and more complete explanation of the facts is afforded by the established principles of variation and natural selection' (Wallace, 1889, p. 431). In relation to Cope's key examples, the growth of intelligence and the development of the ungulate foot, Wallace argued that natural selection was more than capable of generating 'progressive' development by preserving optimal conditions, whether these be intelligence or efficient locomotion. Wallace went even beyond Darwin (who in his later works became more amenable for some measure of Lamarckian inheritance), by arguing vehemently against the inheritance of any acquired characteristics, citing August Weismann's studies on heredity. Any inheritance of acquired characteristics 'are so small in comparison with the amount of spontaneous variation of every part of the organism that they must be quite overshadowed by the latter … Natural Selection is supreme, to an extent which even Darwin himself hesitated to claim for it.' (Wallace, 1889, p. 444)

However, while Wallace was certainly opposed to the directly metaphysical models which were being presented by palaeontological writers like Cope, he nevertheless maintained a strong notion of progress, and even a spiritual agency, in the broader pattern of life's history. Wallace's idea of evolution leading towards increased complexity has already been noted – and should not really be surprising, as this was a common feature of much evolutionary discourse of the period. Likewise, Wallace's main controversial stance in his understanding of evolution, that he did not see it as capable of forming humans, who would have needed some spiritual intervention, also required a strong metaphysical component.

However, Wallace also saw a wider providential and spiritual power as forming a context for the whole development of life. Much of Wallace's interpretation of how natural selection worked in the fossil record drew from an idea of slowly changing climate, as it cooled from an original molten state (a very common notion for the period, also seen in Lankester). Despite this, Wallace saw the maintenance of the climate across geological time within relatively narrow bounds suitable for life as so surprising that it must indicate a protective higher power of some sort. He cited that:

> That the temperature of the earth's surface should have been kept within such narrow limits as it has been kept during the enormous cycles of ages that have elapsed since the Cambrian period of geology, is the more amazing when we consider that it has always been losing heat by radiation into the intensely cold stellar spaces; that it has always, and still is, losing heat by volcanoes and hot springs to an enormous extent; and that these losses are only counteracted by solar radiation and the conservative effect of our moisture-laden atmosphere, which again depends for its chief conservative effect on the enormous extent of our oceanic areas. That all these agencies should have continued to preserve such a uniformity of temperature that almost the whole land surface is, and has been for countless ages, suitable for the continuous development of the world of life, is hardly to be explained without some Guiding Power over the cosmic forces which have been brought about the result. (Wallace, 1914, pp. 186-7)

This means that Wallace was not opposed to spiritual models: just that he believed these worked on a much higher level. Evolution on the level of the organism worked through Darwinian processes of natural selection, but the larger context of development in which this operated had been set up by a higher power.

As with Lankester, the notion of extinction also exercised Wallace a great deal, particularly large-scale extinctions, such as those at the Permian-Triassic boundary, between the Age of Reptiles and the Age of Mammals, and the disappearance of large mammals during the Pleistocene. These were partly explained away through the incompleteness of the fossil record. With regard to the end Permian extinction, he noted how 'it is probable, however, that these transition periods really occupied a very great length of time, since all known reptiles seem to have originated during this era, though owing to unfavourable circumstances the connecting links have rarely been preserved' (Wallace, 1914, pp. 200-201). A similar case was made for the end Cretaceous extinctions, which would have needed an 'enormous duration so as to afford time for the simultaneous dying out of numerous groups of gigantic reptiles and the development in all the large continents of much higher and more varied mammals.' (Wallace, 1914, p. 191) Any understanding of life's history had to incorporate long-term development and operate in a gradual manner.

Wallace's explanations of these extinctions tended to mix a range of causes - showing the diversity of mechanisms which were posited even by ostensible advocates of natural selection when attempting to understanding the more dramatic instances of change in the fossil record. On the one hand, Wallace was clear that large-scale extinctions could be partly explained by natural selection, with big animals being more vulnerable to climatic shifts owing to their very large food requirements, slow birth-rates and long gestation periods. An additional point was that these creatures tended to be highly-specialized forms that could not adapt to new conditions quickly, and were therefore easily outcompeted by smaller generalists. Interestingly, Wallace did not present the same destructive role for humans as was present in Lankester for the more recent extinctions. For Wallace, humans were the pinnacle of creation, and were therefore an improvementrather than a destructive force. Likewise, citing other large-scale extinctions such as the end of the Permian and Cretaceous seemed to show that this was a fairly regular process, which had occurred at a number of distinct periods, and not just a feature of the Pleistocene.

However, the engagement with palaeontology ensured that Wallace did not present natural selection as the only process at work in these instances. In fact, he also hinted at ideas which linked with non-Darwinian models of evolution. In one case, he spoke reasonably in favour of the possibility of 'evolutionary senility,' a model frequently invoked by palaeontologists to explain the extinction of classes of organism, which posited that – after a particular span of time – they lost the capacity to adapt any further. He noted that:

> There remains, however, the question, well put by Mr Lydekker, whether there is not some general deep-seated cause affecting the life of species, and serving to explain, if only partially, the successive dying out of numbers of large animals involving a complete change in the preponderant types of organic life at certain epochs. (Wallace, 1914 p. 249).

Similarly, a need to explain seemingly monstrous, eccentric and maladapted forms in the fossil record or among living animals was also a pressing concern, particularly as Wallace himself rejected sexual selection as a mechanism which could possibly explain these. To explain certain forms of spiny trilobite, eccentric ammonites or modern animals like the babirusa (a type of pig from Borneo whose males displayed extreme curved tusks), Wallace often turned to notions of rampant development which echoed ideas of monstrosity and orthogenesis. The babirusa, with its eccentrically curving tusks, was a model for how this could occur in a way consistent with natural selection. The animal was protected and isolated in its island habitat, and so could develop in a way which was thoroughly unadaptive and only driven by a mysterious germinal force: 'the ancestral form having been long isolated in a country where there were no enemies of importance, natural selection ceased to preserve them in their original useful form, and the initial curvature became increased by germinal selection, while natural selection only checked such developments as would be injurious to the individuals which exhibited them.' (Wallace, 1914, p. 275) In this way, despite Wallace's ostensible objections to theories deriving from some palaeontologists, he nevertheless was still able to reconcile models which were akin to orthogenesis within his evolutionary theories.

## 1.5 Conclusion

In Britain between the 1870s and 1914, palaeontology and Darwinian thinking could be related together in a variety of different manners. Given the tremendous expansion and theoretical developments within palaeontology in this period, palaeontological models and evidence could not be ignored by evolutionist writers, and could be usefully deployed for a variety of purposes, ranging from providing evidence for gradual development in nature, to stoking wonder and awe at the diversity of the natural world. Darwinian thinkers could use palaeontology to depict evolution as gradual and incremental, and recognizable from aligning fossil evidence across geological time and with modern organisms. Other issues, such mechanisms like natural selection or the development of intelligence, tended to be more unevenly engaged with, but were forcefully presented in some instances by individual thinkers.

On a comparative level, this use of palaeontology by these British Darwinian writers is interesting when related to the developments discussed in other papers in this issue, which often show a more uneasy or split relationship between Darwinism and palaeontology in other national contexts (as can be see in the contributions by Bowler, Tamborini, Podgorny and Yu). Partly this is due to the selection of figures investigated. As noted above, Huxley, Lankester and Wallace were thinkers who explicitly committed themselves to be public defenders of Darwinian thinking (even if they often had highly personal takes on the theory). Other British palaeontologists – such as Seeley and Broom – show trends which were more like some of their American and German counterparts, who either deployed Darwinian concepts in a fairly rhetorical fashion while either adopting a non-theoretical perspective or proposing strongly directional modes of evolution. However, it is also partly due to the prominence of gradualist strains of thinking in palaeontology and the prestige of Darwinian thinking within British intellectual society at the time. The gradualistic geological focus of much British palaeontology could link closely with the more gradualist strands in Darwin's models of evolution in a potentially synergistic manner. Likewise, the importance of Darwin for British intellectual culture in this period (even during the ostensible 'Eclipse of Darwinism' as a theory) meant that invoking Darwinian models remained a powerful tool of promoting science.

The reconciliation of Darwinism and palaeontology was also possible through an increased valuation and assertion of progress – whether this be in the natural world or in terms of modern science – but also (particularly among the later writers, Lankester and Wallace) alongside fear of extinction and decline. It has become increasingly frequent to argue that late-nineteenth century invocations of Darwinian thinking frequently glossed over the potentially unsettling aspects of the theory, and used it to reinforce contemporary valuations of progressive improvement in nature. The developments discussed in this article illustrate that an important role in this was played by palaeontology, which was developing narratives, models and theories which were also strongly based around progress and increasing complexity, leading up to humans. These notions were strongly engaged with, and often taken on, by ostensibly Darwinian thinkers and incorporated into their discussions of development. Fossils, evolution and progress could therefore be strongly linked, and synthesizing Darwinian evolution with palaeontological evidence could drive this process.

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